

<b>Comparison between the EIHP Draft Regulations and the ISO Draft Standards on compressed gaseous hydrogen fuel tanks for land vehicles:</b>		<b>ISO report Part 1</b>
EIHP Draft regulations: Uniform Provisions Concerning the Approval of : I Specific Components of Motor Vehicles Using Compressed Gaseous Hydrogen; II. Vehicles with Regard to the Installation of Specific Components for the Use of Compressed Gaseous . Rev. 8.	ISO/CD 15869-1 (ISO/TC 197 doc. N 172) to ISO/CD 15869-5 (ISO/TC 197 doc. N 176 - 2001-05-14) Gaseous hydrogen and hydrogen blends – Land vehicle fuel tanks	<b>Date: 2002-05-24</b>

<b>Clause in EIHP draft regulations</b>	<b>Clause in ISO draft standards</b>	<b>Initial comments on revision 8 of the EIHP draft regulation</b>	<b>Revised comments after reviewing revision 9 of the EIHP draft regulation</b>	<b>Observations on each comment submitted</b>
General	General	<p>The EIHP draft is based on an early draft of ISO 15869, prior to the ISO/CD 15869 draft dated 14 May 2001 and distributed as ISO/TC197 N172-N176 (and ISO/TC58/SC3 N954-N958), and prior to the comments contained in ISO/TC197 N189-N193 (ISO/TC58/SC3 N968-N972), and the response to comments generated at the October 2001 meeting of ISO/TC197/WG6, at which time some changes were adopted in response to the comments. As such, the EIHP draft does not incorporate several changes agreed to by national standards bodies and international committee experts.</p> <p>We have not compared the documents word-for-word, as this is difficult based on changes made to the ISO 15869 document and the EIHP draft since the point in time EIHP baselined from the ISO document; however, we have noted below some of the significant issues.</p>	The EIHP Draft (Revision 9) has been updated to reflect later revisions to the ISO document. In addition to editorial and technical changes, some rearrangement of requirements has been made. There has not been sufficient time to review all requirements. Instead, the review has focussed on reviewing how the previous differences were addressed in the latest draft. There are some added requirements that will be addressed in the future.	
2.1.15		The EIHP draft regulation defines a “Design Pressure” as being the working pressure multiplied by 1.25. The ISO 15869 Working Group (ISO WG) did not intend for this definition to be made or used in determining burst pressures. Also, the ISO WG standard is addressing hydrogen-methane blends as well as pure hydrogen, so the maximum expected operating pressure needs to be 1.3 times working pressure to accommodate methane.	Resolved-the definition of “Design Pressure” was removed.	
2.1.37		<p>The EIHP draft regulation defines a “Pressure Relief Device” as a device that prevents a pre-determined pressure from being exceeded by relieving the pressure. The ISO 15869-1 does not include a definition of a pressure-relief device.</p> <p>Comment: The relief devices used by the industry are generally activated by high temperature, not by pressure. In a fire, these devices act quickly to vent the tank(s) before the heat from the fire can cause a pressure rise. In the event of an elevation in temperature to a point just below the activation temperature of the PRD, the pressure in the tank could exceed the intended maximum pressure of the tank.</p>	Resolved-the definition has been revised to more closely reflect how the pressure relief devices are functioning.	
2.1.43		The EIHP draft regulation defines a “Safety Device” as a device intended to ensure safe operation. The ISO 15869-1 does not include a definition of a safety device.	No change	

<b>Comparison between the EIHP Draft Regulations and the ISO Draft Standards on compressed gaseous hydrogen fuel tanks for land vehicles:</b>		<b>ISO report Part 1</b>
EIHP Draft regulations: Uniform Provisions Concerning the Approval of : I Specific Components of Motor Vehicles Using Compressed Gaseous Hydrogen; II. Vehicles with Regard to the Installation of Specific Components for the Use of Compressed Gaseous . Rev. 8.	ISO/CD 15869-1 (ISO/TC 197 doc. N 172) to ISO/CD 15869-5 (ISO/TC 197 doc. N 176 - 2001-05-14) Gaseous hydrogen and hydrogen blends – Land vehicle fuel tanks	<b>Date: 2002-05-24</b>

Clause in EIHP draft regulations	Clause in ISO draft standards	Initial comments on revision 8 of the EIHP draft regulation	Revised comments after reviewing revision 9 of the EIHP draft regulation	Observations on each comment submitted
2.2		The EIHP draft regulation lists a "Type 5 (Other)" as a container type while the ISO 15869 does not. Comment: There are no stated requirements for such types in the EIHP document and none are known to be in service or development.	No change	
2.3		The ISO/CD 15869-1 does not include a classification of fuel tanks according to working pressure.		
2.4.5	ISO/CD 15869-1, clause 4.8	Comment: The reference should be listed as follows: ISO 14687:1999/Cor 1:2001. This standard was published in 1999 and a technical corrigendum was issued in 2001.		
2.4.7	ISO/CD 15869-1, clause 4.5	The intent of this section of the EIHP draft regulation on re filling and pressure cycles is consistent with the intent of the ISO WG, but the implementation is significantly different. In addition, the current ISO 15869 does not permit a reduction in the minimum of filling cycles if a "Usage Monitoring and Control System" is used.	No change	
4.3	ISO/CD 15869-1, clause 6	The requirements for tank volume, empty weight, and maximum filling mass of hydrogen in the EIHP draft regulation are not included in ISO 15869-1. The year and month of manufacture have to be marked according to ISO 15869-1 while the EIHP draft requires the marking of the year and month of approval. The EIHP draft requires that the serial number on the label and on the exposed surface match The current ISO 15869 only requires that the tank be positively identified, not that the serial numbers match. The identification of the tank content is different.: <ul style="list-style-type: none"> <li>• EIHP: CGH<sub>2</sub>,</li> <li>• ISO: H and blends only</li> </ul>	Resolved-informational items have been removed from the label, the manufacture date is now required, and the serial numbers need not match.  No change-identification of contents	
6.3.1.1		The ISO draft standard does not cover the requirements for the pressure relief valve. Nevertheless, the EIHP draft regulation requires that PRDs shall be temperature triggered only. Comment: This requirement would eliminate the use of a PRD that is temperature triggered but also includes a secondary mechanism for pressure release	Resolved-requirements reworded.	

<b>Comparison between the EIHP Draft Regulations and the ISO Draft Standards on compressed gaseous hydrogen fuel tanks for land vehicles:</b>		<b>ISO report Part 1</b>
EIHP Draft regulations: Uniform Provisions Concerning the Approval of : I Specific Components of Motor Vehicles Using Compressed Gaseous Hydrogen; II. Vehicles with Regard to the Installation of Specific Components for the Use of Compressed Gaseous . Rev. 8.	ISO/CD 15869-1 (ISO/TC 197 doc. N 172) to ISO/CD 15869-5 (ISO/TC 197 doc. N 176 - 2001-05-14) Gaseous hydrogen and hydrogen blends – Land vehicle fuel tanks	<b>Date: 2002-05-24</b>

<b>Clause in EIHP draft regulations</b>	<b>Clause in ISO draft standards</b>	<b>Initial comments on revision 8 of the EIHP draft regulation</b>	<b>Revised comments after reviewing revision 9 of the EIHP draft regulation</b>	<b>Observations on each comment submitted</b>
6.3.1.2		The EIHP draft regulation requires the PRD to be a fusible plug type activated at 120C.  Comment: This will eliminate several successful and potential PRDs from use. First, some devices are being developed which are temperature activated, but not fusible. Second, devices are in use that use fusible “triggers” rather than a fusible “plug”. Third, many of the devices use a fusible alloy that activates slightly above 100C. Service conditions are such that, outside of the engine compartment, the PRD environment should not approach 100C, and the PRD should not be located in the engine compartment	Resolved-requirements reworded.	
14.3.2.4		The EIHP draft regulation requires a second PRD for containers greater than 1.65m long while the ISO 15869 does not.  Comment: An innovative PRD design might allow a single PRD to function safely. On the other hand, this would appear to deny the use of a manifold that uses 3 PRDs for a long tank, as is being used successfully in the field. This wording also implies that the PRD must be in the boss, while the requirement in its simplest form is that the PRD cannot be valved off from the cylinder. Again, manifold systems are being used successfully in the field.	Resolved-requirements harmonized with ISO 15869.	
Annex 7 4.3.2	ISO/CD 15869-1, clause 5.2.1.2.3	In ISO/CD 15869-1, no exception is granted for the stress analysis for tanks built according to ISO 9809.	Partially resolved-Draft 9 does not require a stress analysis report.	
Annex 7 4.3.6 and 5.11	ISO/CD 15869-1	The fuel tanks supports are not covered in ISO/CD 15869-1.	Resolved-tank supports were removed.	
Annex 7 5.3	ISO/CD 15869-2, ISO/CD 15869-3, clauses 5.2 and 5.3  ISO/CD 15869-4, clauses 5.2 and 5.3	The EIHP draft regulation defines requirements for steel and aluminum. ISO 15869 has now referred to the materials requirements of ISO 9809-1 and ISO 7866, respectively.	Partially resolved-ISO 9809 and 7866 have been referenced. Applicability to Type 4 bosses should be reviewed.	

<b>Comparison between the EIHP Draft Regulations and the ISO Draft Standards on compressed gaseous hydrogen fuel tanks for land vehicles:</b>		<b>ISO report Part 1</b>
EIHP Draft regulations: Uniform Provisions Concerning the Approval of : I Specific Components of Motor Vehicles Using Compressed Gaseous Hydrogen; II. Vehicles with Regard to the Installation of Specific Components for the Use of Compressed Gaseous . Rev. 8.	ISO/CD 15869-1 (ISO/TC 197 doc. N 172) to ISO/CD 15869-5 (ISO/TC 197 doc. N 176 - 2001-05-14) Gaseous hydrogen and hydrogen blends – Land vehicle fuel tanks	<b>Date: 2002-05-24</b>

<b>Clause in EIHP draft regulations</b>	<b>Clause in ISO draft standards</b>	<b>Initial comments on revision 8 of the EIHP draft regulation</b>	<b>Revised comments after reviewing revision 9 of the EIHP draft regulation</b>	<b>Observations on each comment submitted</b>
Annex 7 5.3.1 and A.27		The hydrogen compatibility test is not specified in ISO 15869, as these would be referenced directly by ISO 9809.	Partially resolved-hydrogen compatibility removed here, later called out referencing ISO/CD 11114-4, which is unreleased, and applicable only to steel.	
Annex 7 5.3.6	ISO/CD 15869-1, clause D.21	The EIHP draft regulation defines softening (130C) and melting (160C) points for plastic liners. The ISO 15869-1 requires that the softening temperature of plastic be at least 100 °C. Comment: There are many hydrogen tanks being used successfully on vehicles which have liners that would not meet the EIHP draft requirement, but do been the ISO requirement..	Partially resolved-Softening/melt temperatures now are referenced at 100C and 130C respectively. Existing materials could be used, but still a consideration as to whether the 130C melt requirement is useful, and if it would restrict technology.	
Annex 7 5.4	ISO/CD 15869-3, clause 6.1 ISO/CD 15869-4, clause 6.1 ISO/CD 15869-5, clause 6.1	The EIHP draft regulation defines the test pressure as 1.5 times "Design Pressure" which in turn is 1,25 times the working pressure. ISO 15869 defines the test pressure as 1.5 times the working pressure.	Resolved-now test pressure is 1.5 times working pressure.	
Annex 7 5.5	ISO/CD 15869-3, clause 6.2 ISO/CD 15869-4, clause 6.2 ISO/CD 15869-5, clause 6.2	The EIHP draft regulation defines the burst pressure in terms of the "Design Pressure" (1,25 times the working pressure). ISO 15869 defines the burst pressure in terms of the working pressure. .	Resolved-now burst pressure is based on working pressure	
Annex 7 5.10.1		The EIHP draft regulation requires openings in container heads only, centered on the longitudinal axis. This was removed from ISO 15869 in order to allow innovative designs.	Resolved-the requirement was removed.	

<b>Comparison between the EIHP Draft Regulations and the ISO Draft Standards on compressed gaseous hydrogen fuel tanks for land vehicles:</b>		<b>ISO report Part 1</b>
EIHP Draft regulations: Uniform Provisions Concerning the Approval of : I Specific Components of Motor Vehicles Using Compressed Gaseous Hydrogen; II. Vehicles with Regard to the Installation of Specific Components for the Use of Compressed Gaseous . Rev. 8.	ISO/CD 15869-1 (ISO/TC 197 doc. N 172) to ISO/CD 15869-5 (ISO/TC 197 doc. N 176 - 2001-05-14) Gaseous hydrogen and hydrogen blends – Land vehicle fuel tanks	<b>Date: 2002-05-24</b>

<b>Clause in EIHP draft regulations</b>	<b>Clause in ISO draft standards</b>	<b>Initial comments on revision 8 of the EIHP draft regulation</b>	<b>Revised comments after reviewing revision 9 of the EIHP draft regulation</b>	<b>Observations on each comment submitted</b>
Annex 7 5.10.3	ISO/CD 15869-4, clause 7.2  ISO/CD 15869-4, clause 7.3  ISO/CD 15869-4, clause 7.2	The EIHP draft regulation requires calculations to be run on straight threads. ISO 15869 removed such requirements and specified that threads be made to accepted international standards.	Resolved-now allows threads meeting national or international standards.	
Annex 7 6	ISO/CD 15869-2	The EIHP draft regulation establishes requirements for Type 1 (metal) containers. ISO 15869-2 was changed to require containers to conform with ISO 9809-1 (steel) or ISO 7866 (aluminum).	Resolved-ISO 9809 and ISO 7866 are now referenced.	
Annex 7 9.2, 9.6.1 iii and A.24	ISO/CD 15869-1, clause D.4	The EIHP draft regulation requires a torque test on the end bosses at a level of 500 N-m. This was changed in ISO 15869 to 2 times the torque specified for the valve or fitting. Rationale for the change: On tanks with a small boss and small port opening, it was deemed unrealistic to test to 500 N-m.	Resolved-now uses 2 times the specified torque.	
Annex 7 9.3		The EIHP draft regulation requires calculation of stresses in the non-metallic liner. This requirement was removed from ISO 15869, as the liner is non-loadsharing.	Resolved-stress calculation removed.	
Annex 7 A.1		This section of the EIHP draft regulation has been removed from ISO 15869 with the incorporation of ISO 9809-1 and ISO 7866	No change	
Annex 7 A.2		This section of the EIHP draft regulation has been removed from ISO 15869 with the incorporation of ISO 9809-1 and ISO 7866.	No change	
Annex 7 A.4		This section of the EIHP draft regulation has been removed from ISO 15869 with the incorporation of ISO 9809-1 and ISO 7866.	No change	
Annex 7 A.5		This section of the EIHP draft regulation has been removed from ISO 15869 with the incorporation of ISO 9809-1 and ISO 7866.	No change	
Annex 7 A.6	ISO/CD 15869-1, clause D.16	The EIHP draft regulation requires cycling to 15,000 cycles. ISO 15869 requires 45,000 cycles.	Partially resolved-15,000 cycle requirement removed, now must go to failure.	

<b>Comparison between the EIHP Draft Regulations and the ISO Draft Standards on compressed gaseous hydrogen fuel tanks for land vehicles:</b>		<b>ISO report Part 1</b>
EIHP Draft regulations: Uniform Provisions Concerning the Approval of : I Specific Components of Motor Vehicles Using Compressed Gaseous Hydrogen; II. Vehicles with Regard to the Installation of Specific Components for the Use of Compressed Gaseous . Rev. 8.	ISO/CD 15869-1 (ISO/TC 197 doc. N 172) to ISO/CD 15869-5 (ISO/TC 197 doc. N 176 - 2001-05-14) Gaseous hydrogen and hydrogen blends – Land vehicle fuel tanks	<b>Date: 2002-05-24</b>

<b>Clause in EIHP draft regulations</b>	<b>Clause in ISO draft standards</b>	<b>Initial comments on revision 8 of the EIHP draft regulation</b>	<b>Revised comments after reviewing revision 9 of the EIHP draft regulation</b>	<b>Observations on each comment submitted</b>
Annex 7 A.10	ISO/CD 15869-1, clause D.17	The EIHP draft regulation requires no leakage in excess of 0.004 Ncm <sup>3</sup> /hr. ISO 15869 does not establish a leak rate, but does not allow leakage. This allows the manufacturer to assess whether a measured release of gas is likely due to permeation or leakage. If the measured release is below the allowable permeation rate, it should be acceptable. Tanks typically range in size from 100 liters to over 500 liters. ISO 15869 allows a permeation rate of 1 Ncm <sup>3</sup> /hr/liter of water capacity. With the sizes noted, this is 100 Ncm <sup>3</sup> /hr to 500 Ncm <sup>3</sup> /hr, which is several orders of magnitude above the leak rate specified above.	Partially resolved-Requirement revised to reflect that leakage and permeation requirements are separate and distinct. However, specifying 5%H <sub>2</sub> or 10%He in the mixture adds unneeded expense for a production test on all tanks. With demonstration of capability, lower concentrations or alternate methods should be allowed.	
Annex 7 A.14 and Annex H	ISO/CD 15869-1, clause D.10	The EIHP draft regulation requires an acid environment test. ISO 15869 replaced this test with the formerly informative environmental test (Annex H of the EIHP draft regulation) that had a broader range of exposure to corrosive fluids, with some modifications.	Resolved-now similar to ISO 15869 requirement.	
Annex 7 A.15.8	ISO/CD 15869-1, clause D.3.6	The EIHP draft regulation adds a requirement that the pressure inside the container rise by no more than 5 percent of the pressure at which venting starts.  The ISO 15869 requires only that the PRD vents the container without rupturing. Comment: A 30 percent overpressure is normally allowed in filling.	Resolved-pressure rise limit removed.	
Annex 7 A.17	ISO/CD 15869-1, clause D.8	The EIHP draft regulation allows the manufacturer to establish flaw sizes. ISO 15869 allows the manufacturer to establish flaw sizes, but also requires minimum flaws of 25 mm long by 1.25 mm deep and 200 mm long by 0.75 mm deep. These flaw sizes are reasonable expectations based on field experience.	No change	
Annex 7 A.18	ISO/CD 15869-1, clause D.4	The EIHP draft regulation uses a hold temperature of 95C. ISO 15869 uses a hold temperature of 100C.	No change	
Annex 7 A.19	ISO/CD 15869-1, clause D.1	The EIHP draft regulation requires the container to be submerged in water. ISO 15869 does not. The ISO 15869 test was based on test results that caused a container with known field problems to fail.	Partially resolved-water is not required, but high humidity was added. ISO intended only accelerated test via high temperature re Arrhenius rate equation, while introducing humidity may change response mechanisms of the composite.	

<b>Comparison between the EIHP Draft Regulations and the ISO Draft Standards on compressed gaseous hydrogen fuel tanks for land vehicles:</b>		<b>ISO report Part 1</b>
EIHP Draft regulations: Uniform Provisions Concerning the Approval of : I Specific Components of Motor Vehicles Using Compressed Gaseous Hydrogen; II. Vehicles with Regard to the Installation of Specific Components for the Use of Compressed Gaseous . Rev. 8.	ISO/CD 15869-1 (ISO/TC 197 doc. N 172) to ISO/CD 15869-5 (ISO/TC 197 doc. N 176 - 2001-05-14) Gaseous hydrogen and hydrogen blends – Land vehicle fuel tanks	<b>Date: 2002-05-24</b>

<b>Clause in EIHP draft regulations</b>	<b>Clause in ISO draft standards</b>	<b>Initial comments on revision 8 of the EIHP draft regulation</b>	<b>Revised comments after reviewing revision 9 of the EIHP draft regulation</b>	<b>Observations on each comment submitted</b>
Annex 7 A.20	ISO/CD 15869-1, clause D.9	The EIHP draft regulation requires multiple drops in the vertical and 45-degree orientations.  ISO 15869 requires a single drop in these orientations. Rationale: Containers designed to meet the ISO 15869 requirement, which is the same as in the ISO 11439 for CNG containers, have performed exceptionally in the field. They have demonstrated safety through a number of accidents and incidents in which the containers were subjected to impacts.	Not resolved-an additional horizontal test was added. Note: trying to do two drops on the same area adds non-repeatability, as there is some randomness in the impacts, particularly secondary and tertiary hits.	
Annex 7 A.21	ISO/CD 15869-1, clause D.19	The EIHP draft regulation requires a permeation limit of 0.25 Ncm <sup>3</sup> /hr/liter of water volume and a test of unspecified length.  ISO 15869 requires a limit of 1.0 Ncm <sup>3</sup> /hr/liter with a test length of 500 hours minimum. Rationale: Engineers from Lawrence Livermore National Laboratories have conducted an analysis showing that, based on lower limits of ventilation in garage spaces, an allowable of 40 Ncm <sup>3</sup> /hr/liter would be safe. Therefore, a limit of 1.0 gives an additional safety factor of 40. The 500-hour minimum time is intended to insure that the permeation rate has stabilized.	Resolved-harmonized with the ISO 15869 requirements.	
Annex 7 A.23	ISO/CD 15869-1, clause D.21	The EIHP draft regulation is titled as determining melting temperature of plastics, while ISO 15869 is determining softening point of plastics.	Partially resolved-now titled as softening test, but still has a melt temperature requirement.	
Annex 8A 5		The EIHP draft regulation requires the PRD to be held at test pressure and 100C for 24 hours with no evidence of extrusion, and that brass components be tested per ASTM B154.  Comment: The combined temperature and pressure requirements may cause failure of PRDs which have proven successful in the field, as the 100C is at the level of some fusible materials and above the operating requirements of the vehicle in the areas where the PRD could be mounted. The ASTM B154 test contains environmentally harmful test agents, and has been replaced by testing in a moist ammonia-air environment in other standards.	Partially resolved-temperature reduced from 100C to 95C, but this still may be an issue. ASTM B154 is still referenced.	

Acknowledgments: This comparison was performed with the help of Mr. N. L. Newhouse of Lincoln Composites in cooperation with the ISO/TC 197 Secretariat. We would like to thank Mr. Newhouse for his contribution to this work.